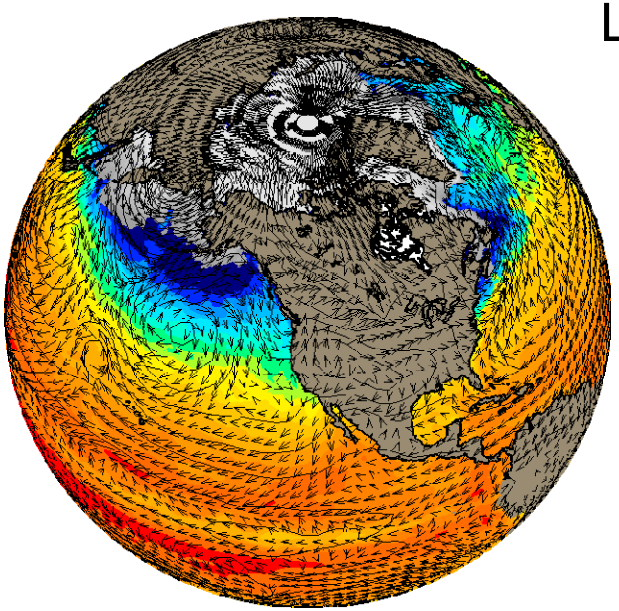
A Briefing on CAM4 Development

Phil Rasch

(Minghua Zhang, Leo Donner)

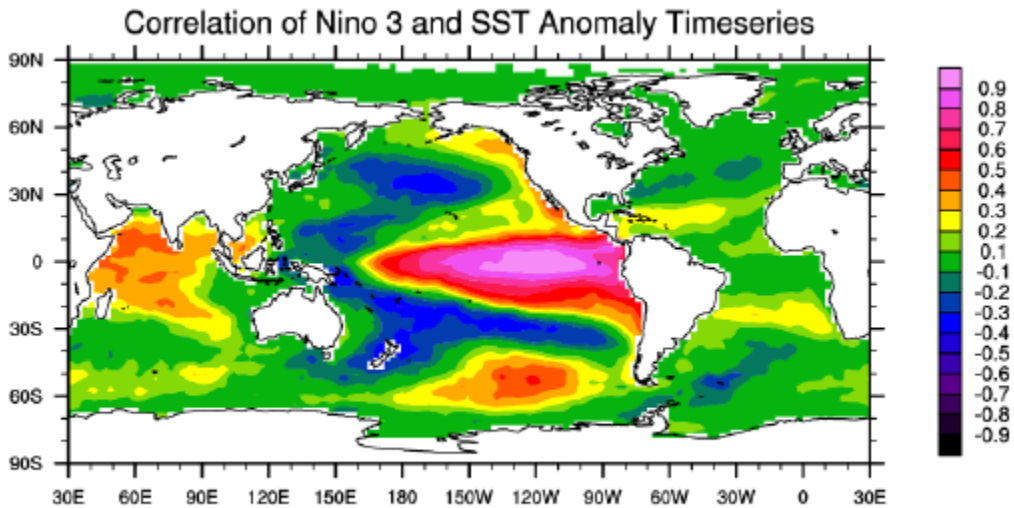
(Bretherton, Cameron-Smith, Collins, Conley, Eaton, Gettelman, Ghan, Hess, Iacono, Lamarque, Lauritzen, Liu, Mahowald, Mitchell, Morrison, Neale, Park, Richter, Sassi, Vitt, many others for software engineering and advice)



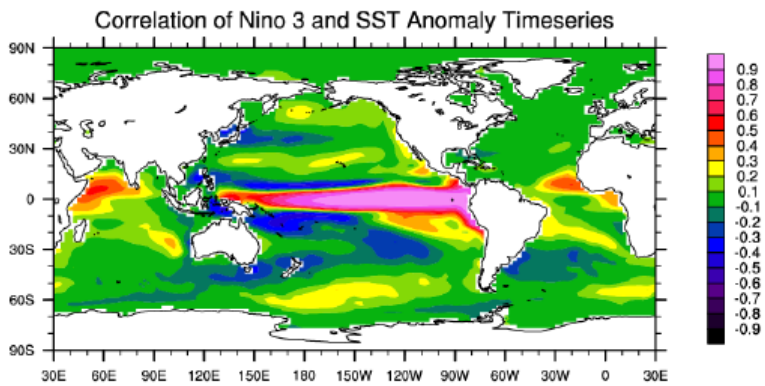
CAM3.5

- Initial definition, Spring, 2007
- Revised convection
  - Neale et al (2008), entrainment mixing in CAPE & cloud height calc
  - Richter and Rasch (2007), cumulus momentum transports
- Freeze dried clouds (cold cloud fraction depends upon condensate mass)
- Changed location of cloud fraction calculation

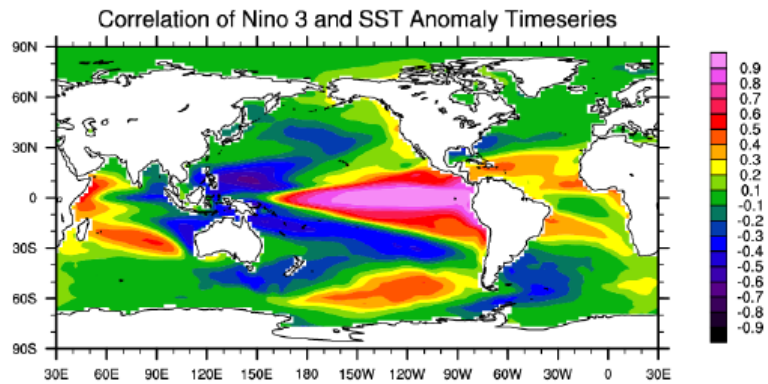
Lag 0 Nino 3 SST Correlation



CAM3



Neale+Richter



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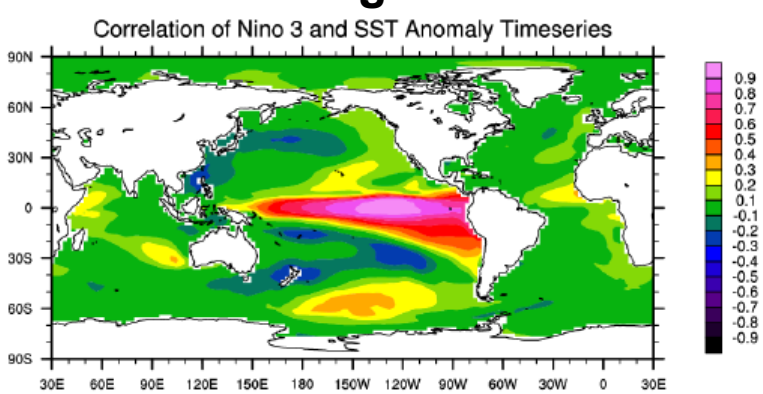

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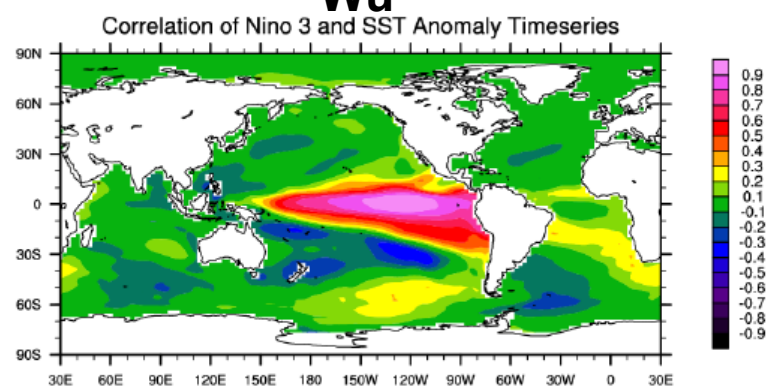
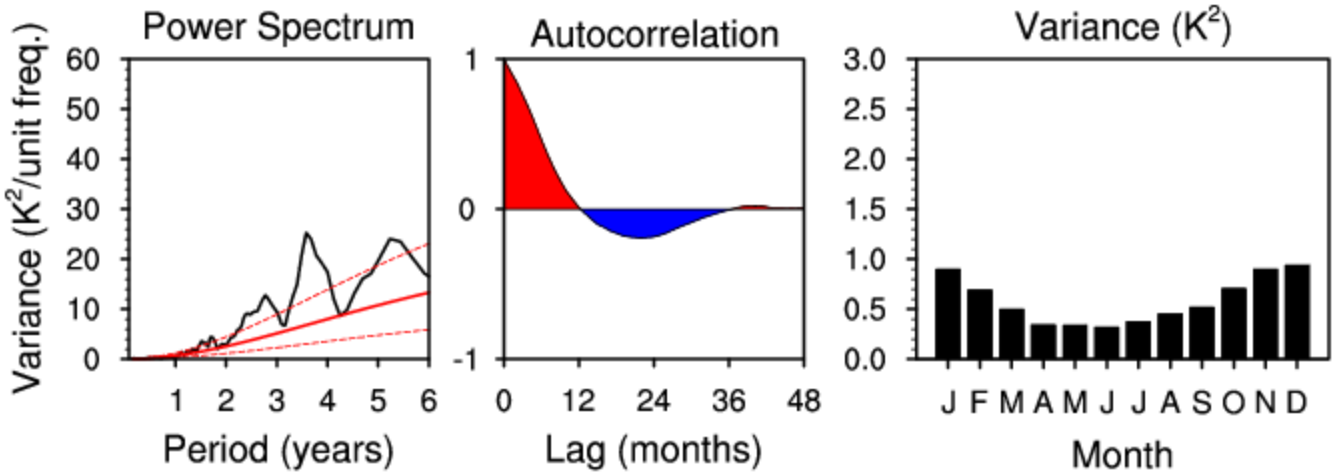


HadiSST
nino3.4 SST



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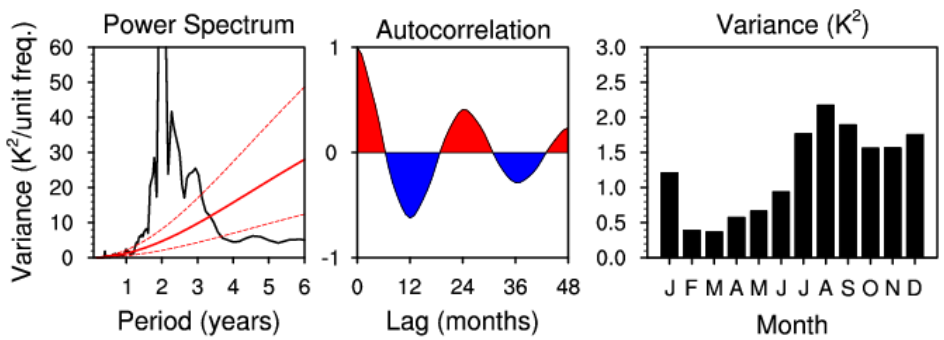

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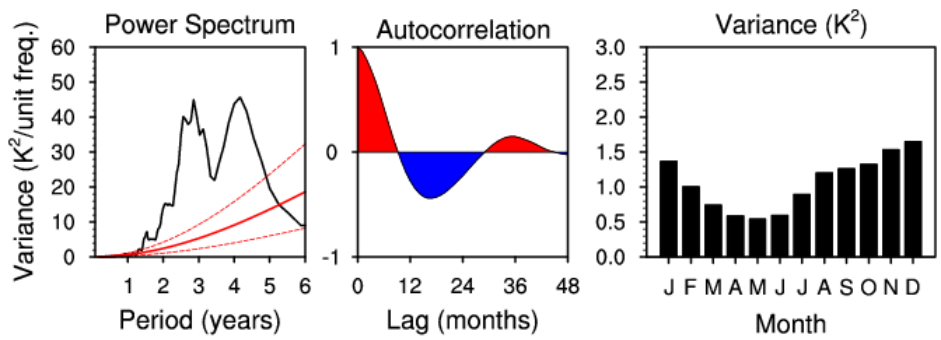

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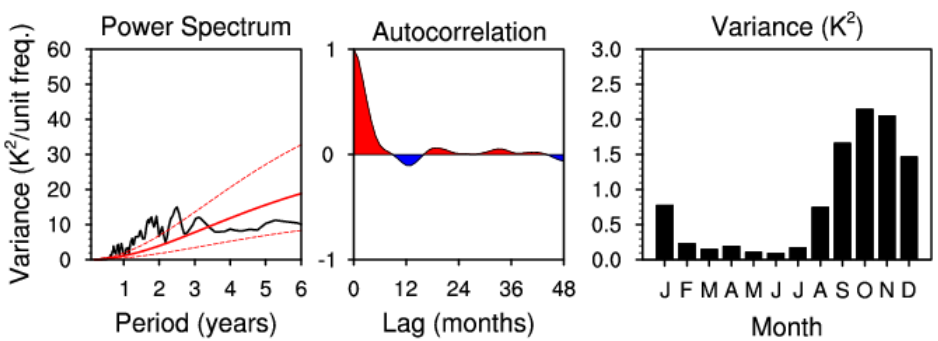

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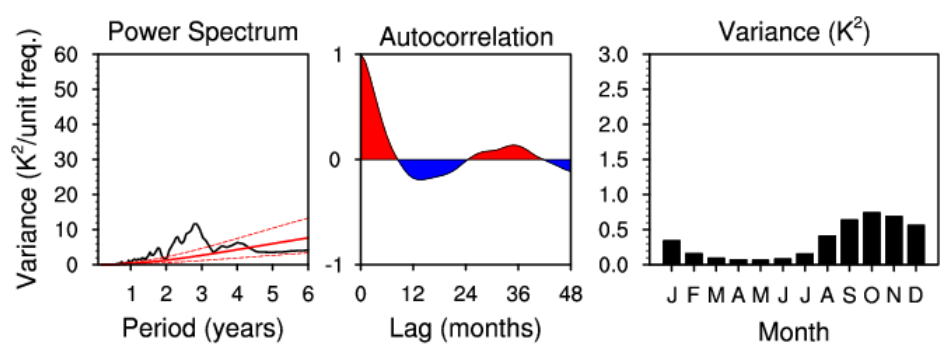
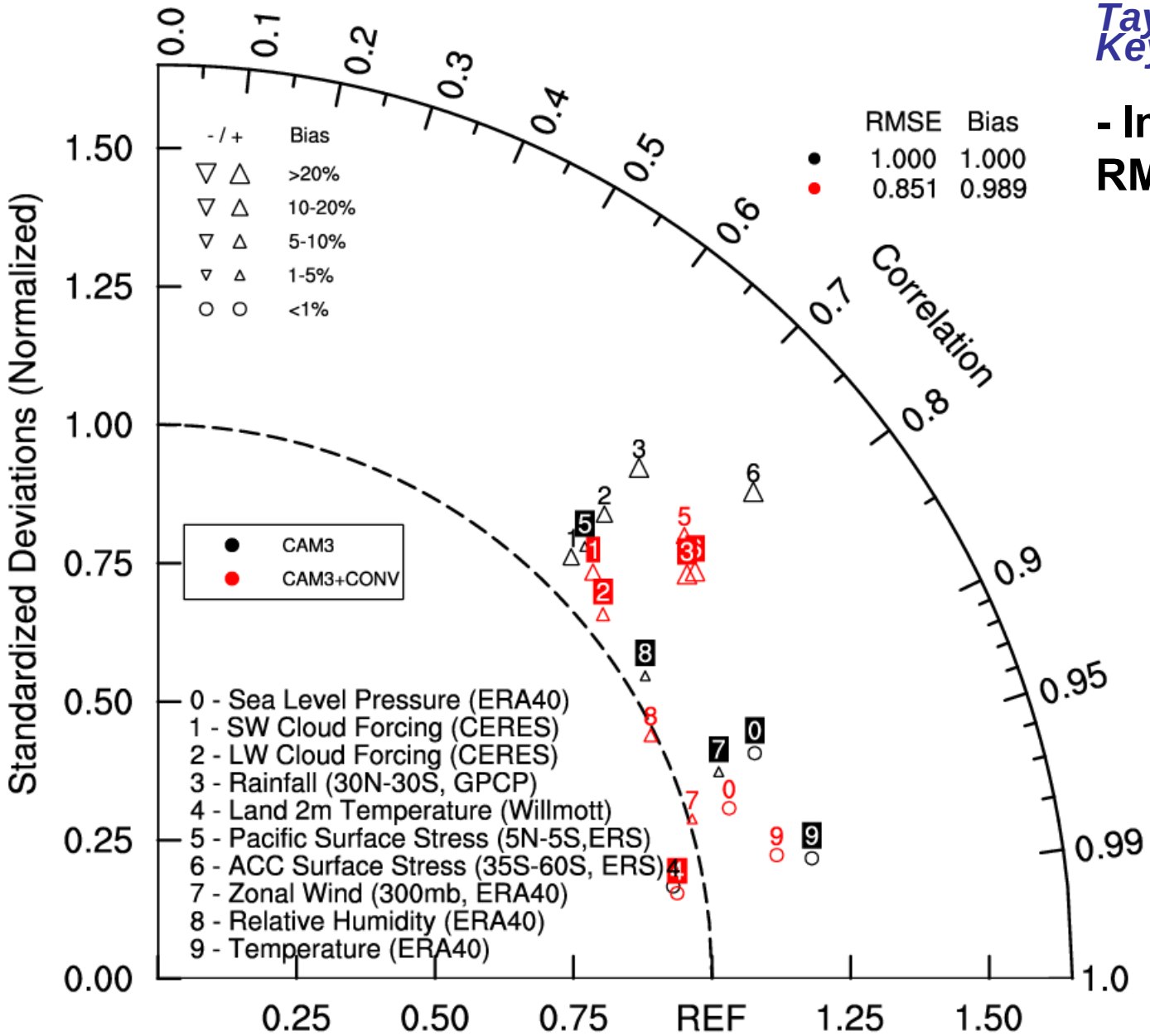




Taylor Diagram of Key Metrics

- Improved mean RMSE by 15%

Annual Cycle of Monthly Means

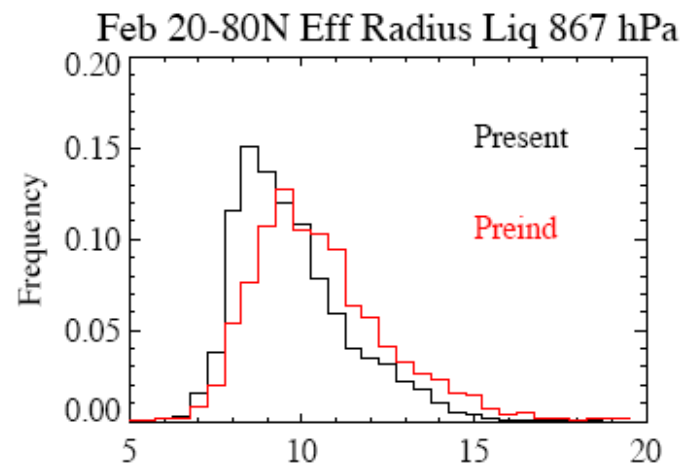
Post CAM3.5

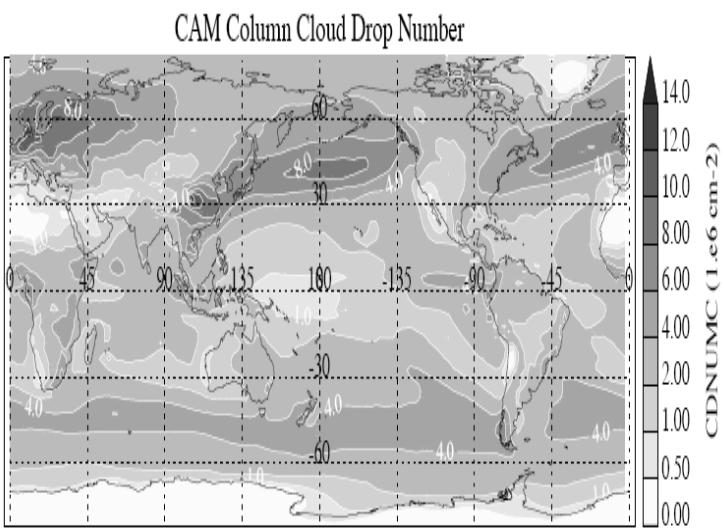
- Aerosols
  - Modal Aerosol treatment by Ghan and Liu
  - Mass and number for 3 or 7 modes
  - Internal/external mixtures
  - Sources follow Mahowald, Hess, Vitt, Bond, Lamarque, Gettelman, Rasch
  - Deposition, Easter, Ghan, Rasch
- Microphysics
  - Morrison and Gettelman 2 moment (mass and number)
  - Abdul-Razzak and Ghan formulation for drop activation
- RRTMG
  - Iacono, Conley, Collins, Mitchell

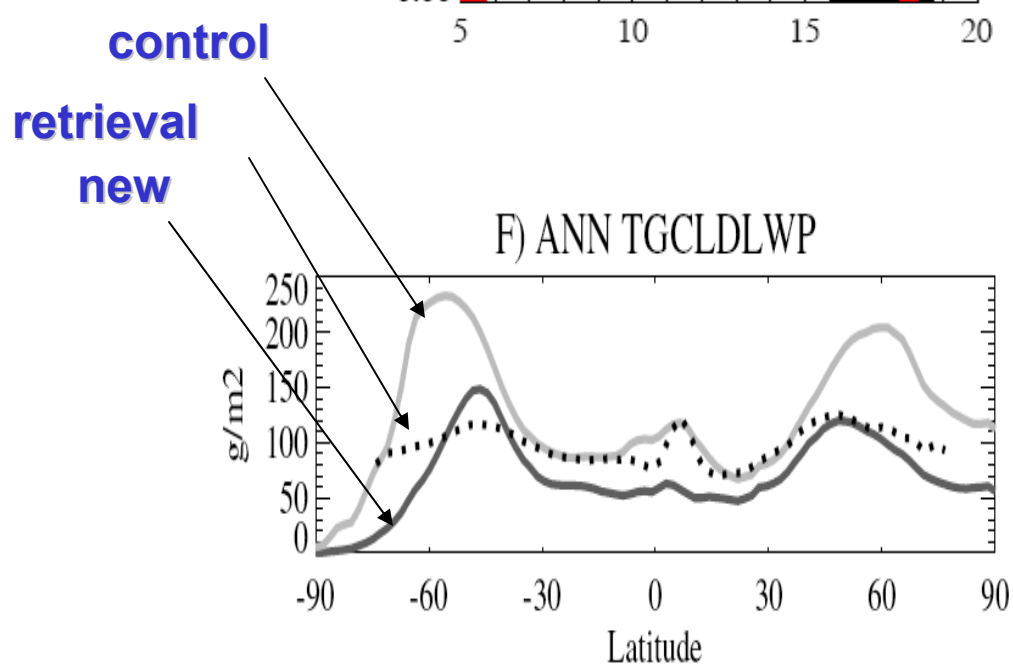
New microphysics (Morrison, Gettelman, Ghan)

- predicts drop number
  - with cloud drop activation provides (indirect effect)
  - Capability for indirect effect is a blessing and curse!
- modern representation of microphysics
  - Including mixed phase processes
- More realistic

Indirect effects of aerosols in CAM: PDF of N. Hemisphere (20-80N) Effective Radius of Liquid Cloud Drops for Present day and Pre-industrial Aerosol Loading at ~850hPa

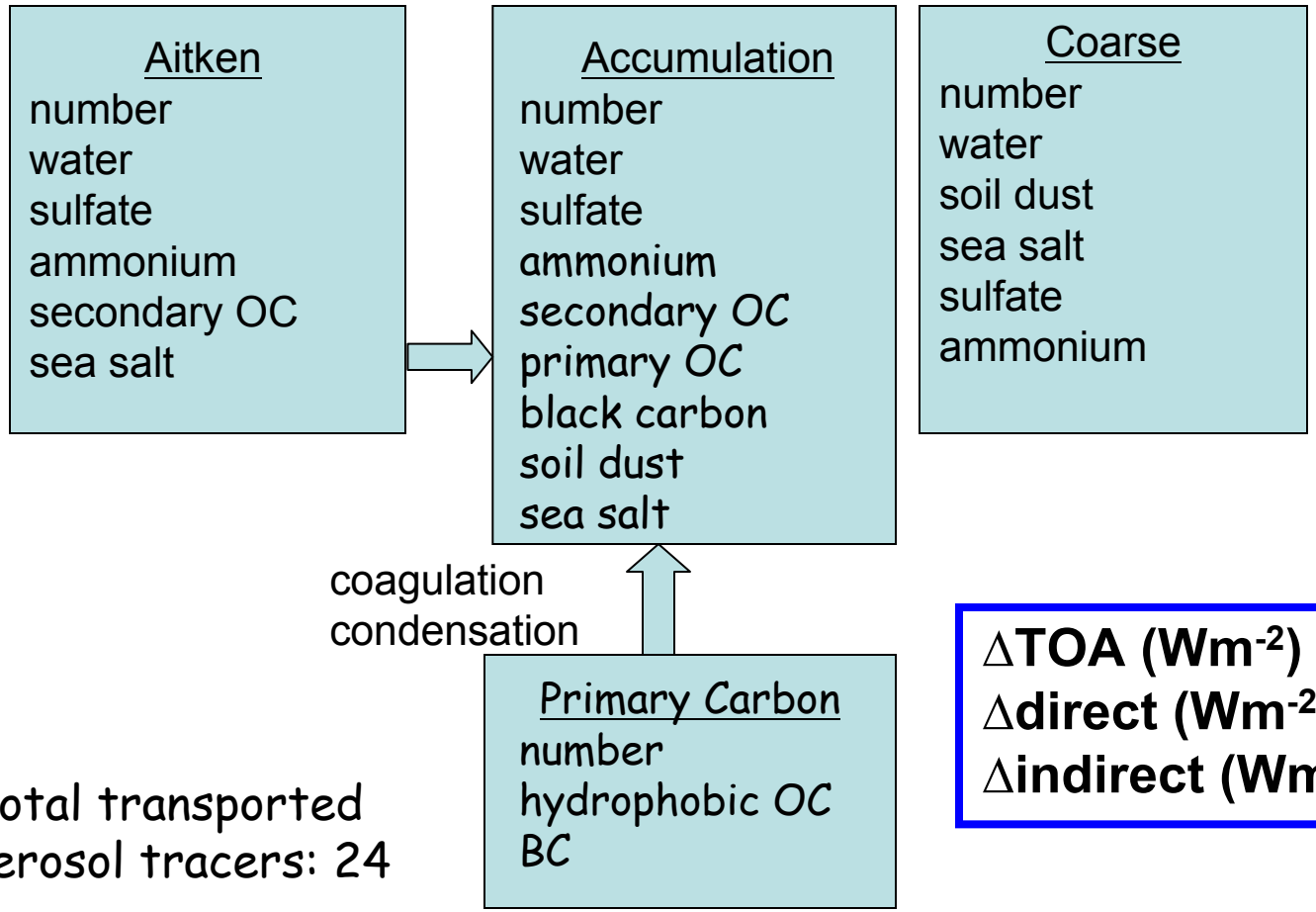






4-mode version of modal aerosol

Carry soil dust and sea salt in same coarse mode because sources are separate.
Move fine dust and sea salt to accumulation mode and eliminate fine modes.



Total transported aerosol tracers: 24

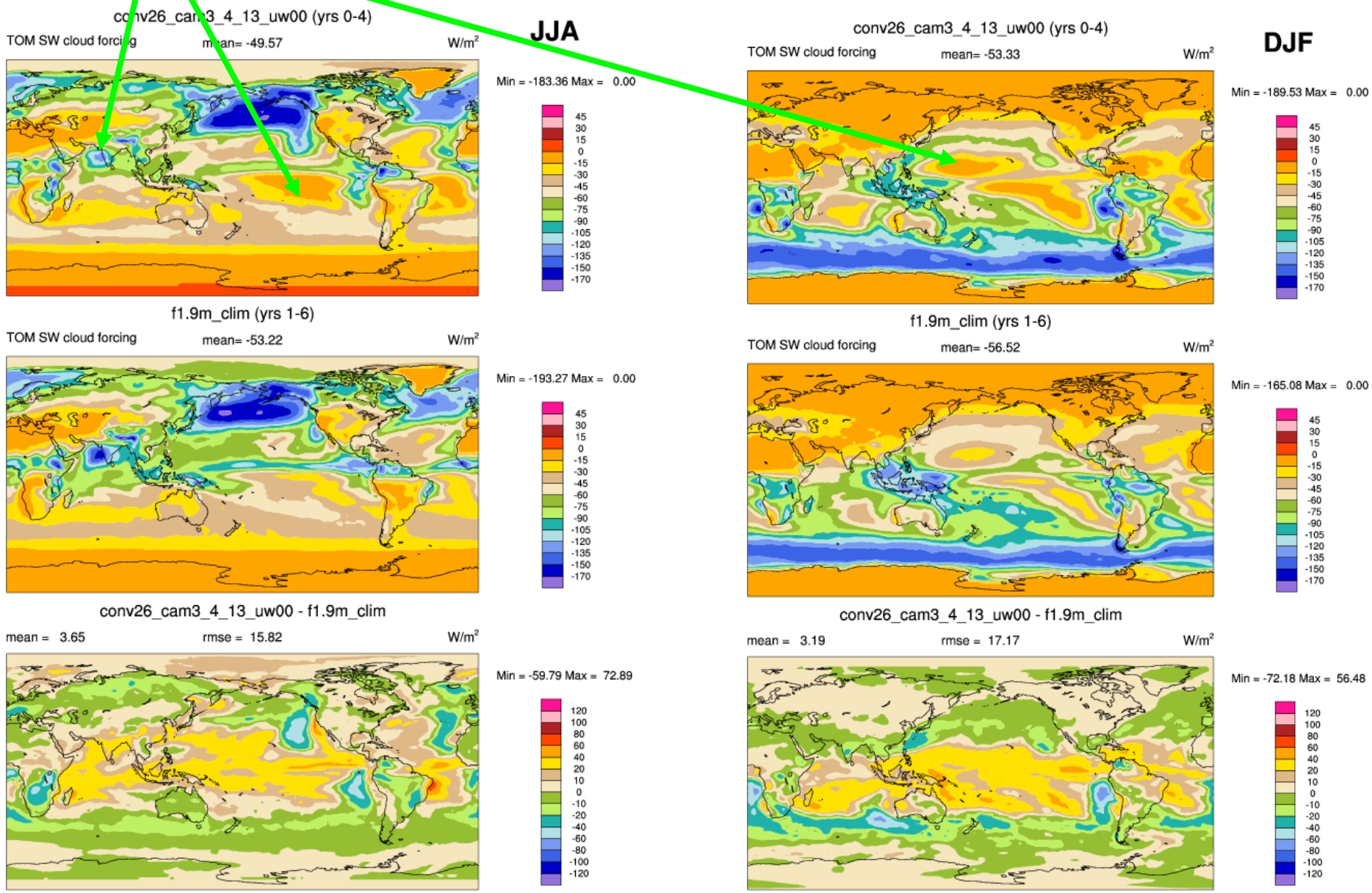
ΔTOA (Wm^{-2}) = -1.2 (7m: -1.5)
Δdirect (Wm^{-2}) = -0.3 (-0.4)
Δindirect (Wm^{-2}) = -0.9 (-1.1)

Final components of development

- UW formulations for Shallow convection and PBL (Bretherton and Park)
- Macrophysics -- internal consistency across stratiform cloud fraction, condensation/evaporation, radiative transfer, PBL and shallow convection (Park, Rasch, Bretherton)
- Ice cloud fraction and microphysical formulation (Gettelman and Morrison)
- Crude use of in-cloud water content, and cloud fraction from deep and shallow convection scheme for radiative transfer (Neale, Rasch, Park)
- Revised Gravity Wave Breaking (Sassi, Richter)

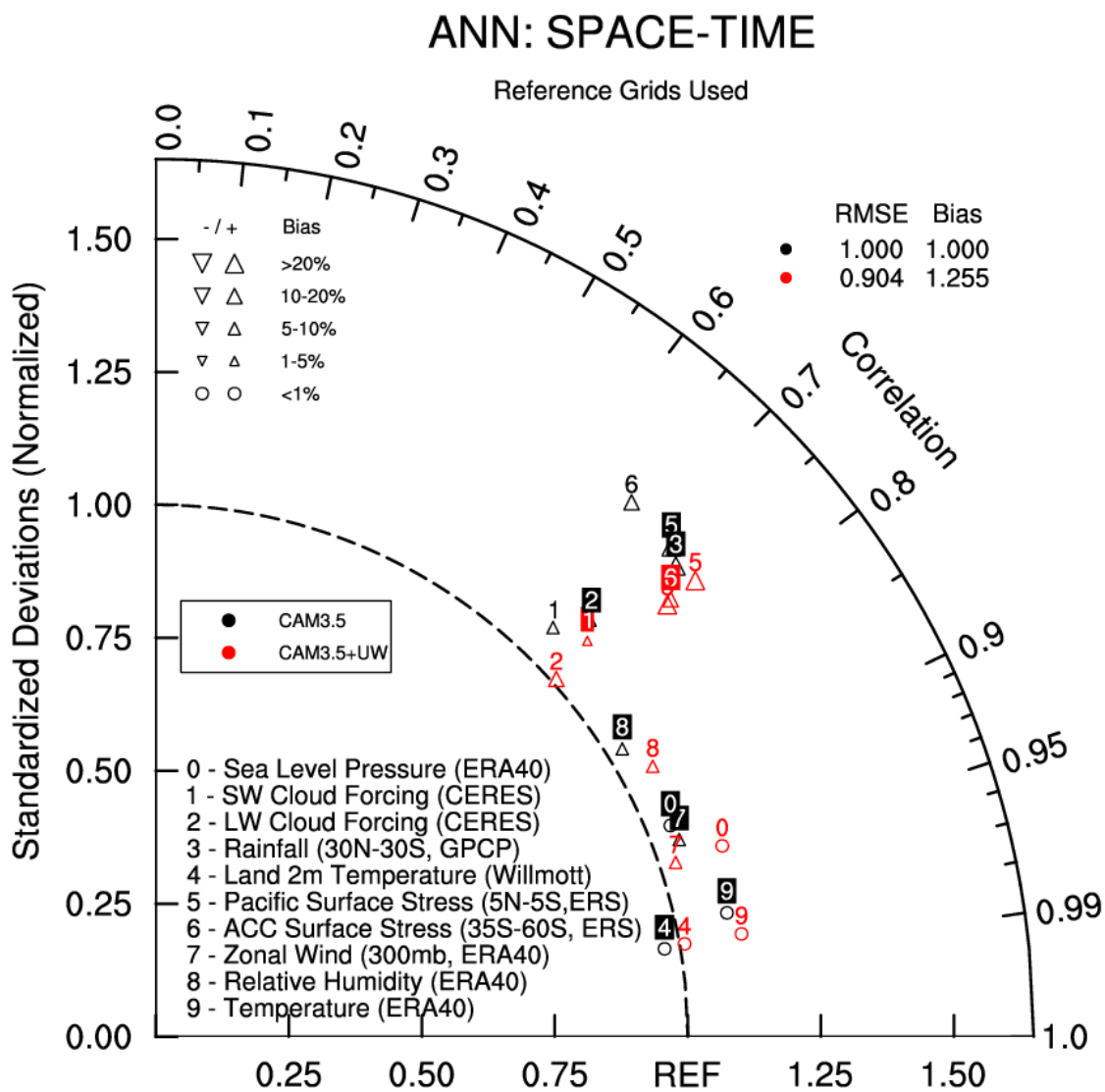
Notice these features!

UW Parameterization
Shortwave Cloud Forcing Change



Taylor Diagram CAM-UW vs CAM3.5

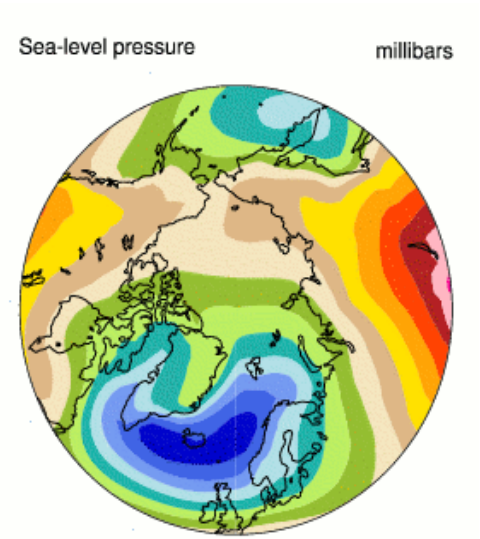
- 10% reduction in RMS error compared to CAM3.5



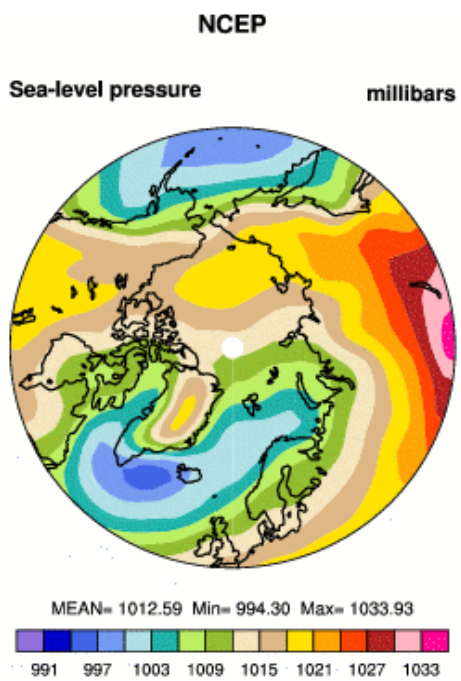
Changes to Mountain drag
Sassi (NCAR)

- Substantial changes to
  - Surface pressure biases
  - Stationary waves
  - Zonal wind

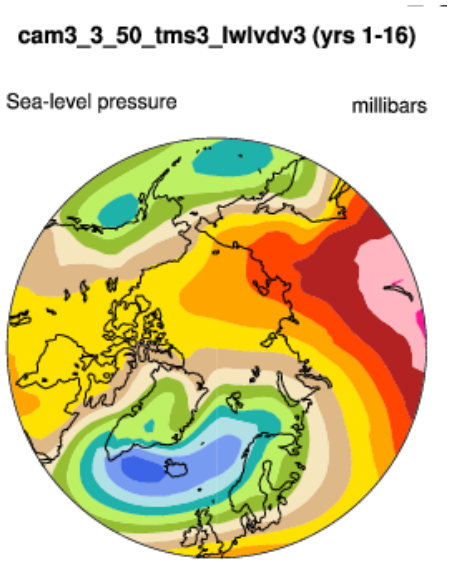
Control



Obs



Mountain Drag



Summary

- CAM4 will have the largest number of changes implemented between one generation and the next of any model since very first generations of CCM
- Probably more involvement by the outside community than any previous model.
- ARM, SCIDAC & CCPP will have made important demonstrable contributions to CAM4.
  (RRTMG, Modal Aerosols, Mitchell Ice optics, CAPT).

Remaining Issues

- Final integration, Tuning, Configuration
  - TOA radiative balance will be to 1870, not present day (requires emissions, not quite ready yet)
  - Time varying volcanic eruptions, solar variability
  - Horizontal and Vertical Resolution
- Hindcast 1870—2000 to see transient simulation character
- Chemistry

ARM Opportunities?

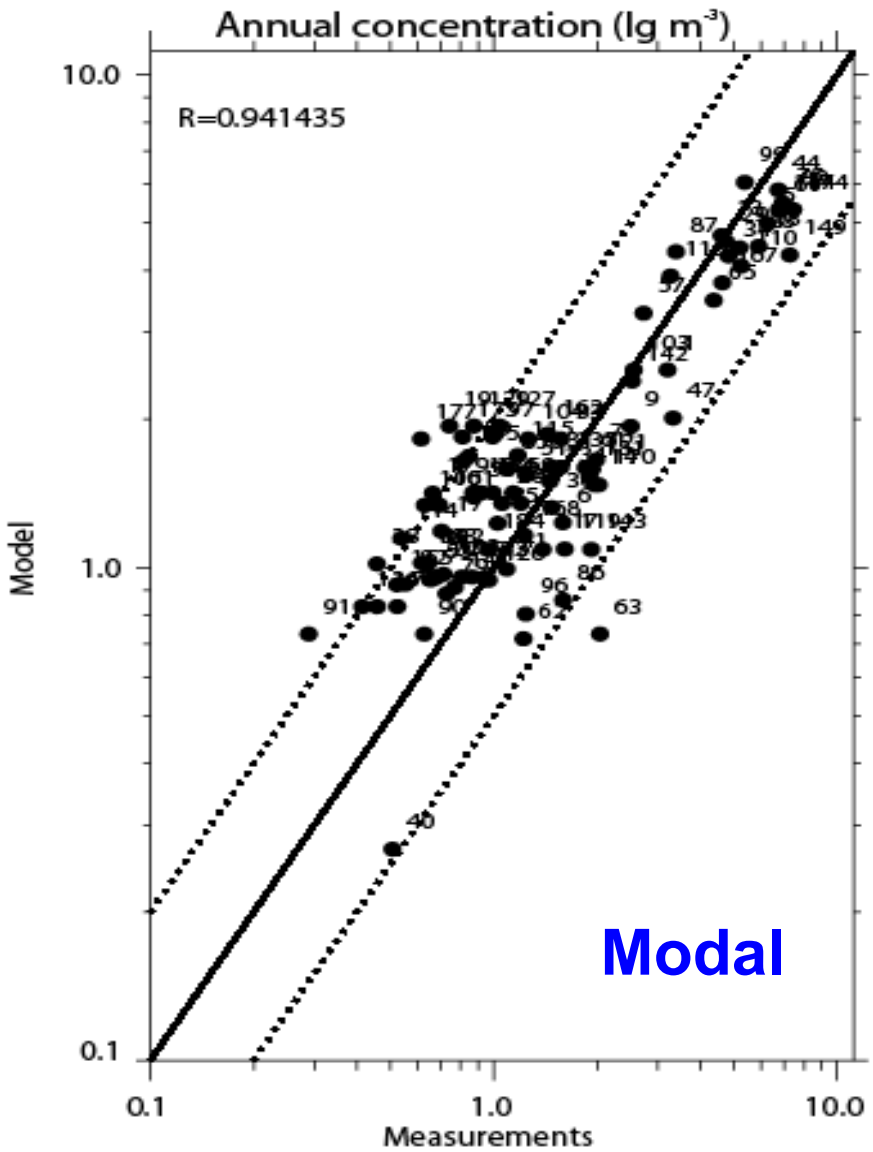
- Little opportunity yet for assessment/validation “retuning” during development
- Water vapor vertical distribution high compared to many analysis products. Is this realistic? Near sfc? Upper trop?
- CERES picture of the radiative budget significantly different from ERBE. Related to water vapor? Sfc vs TOA check?
- Condensate/precipitate distribution still sufficiently uncertain that we have felt relatively unconstrained in tuning. ????

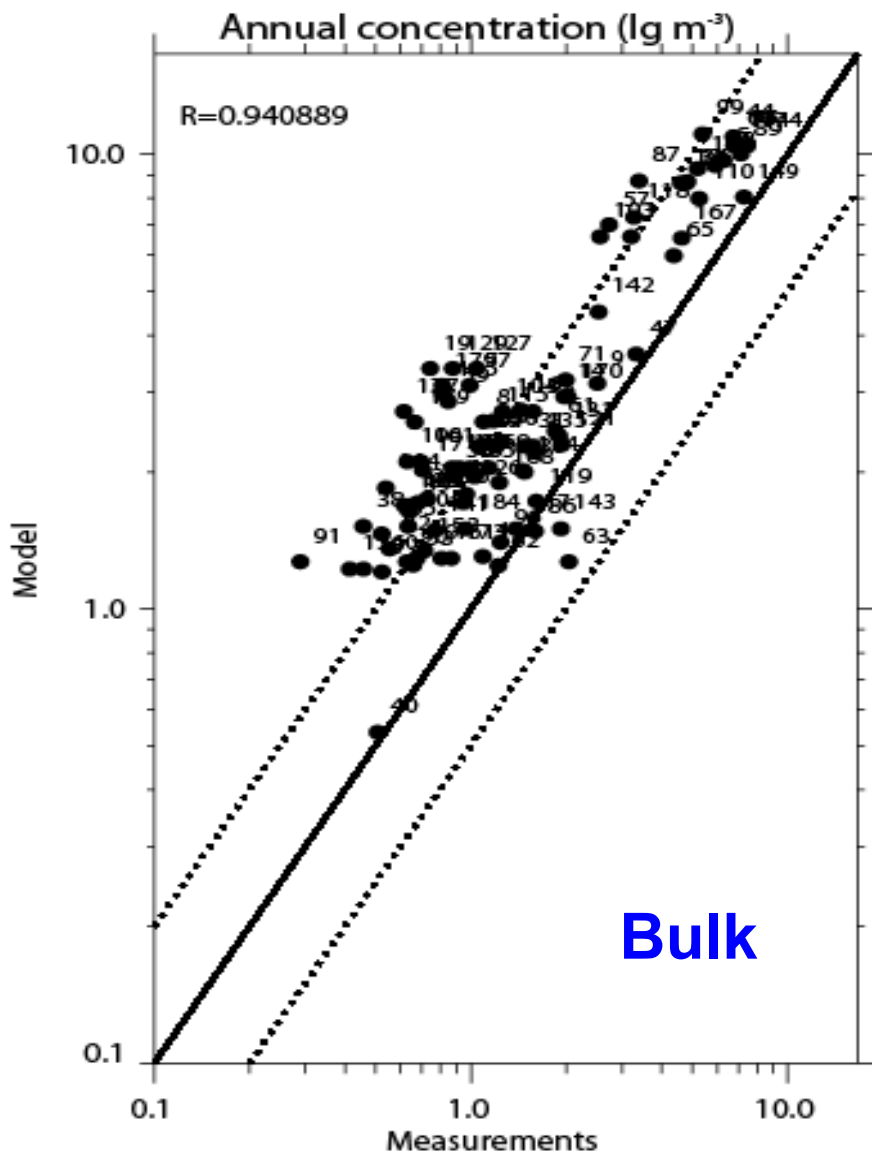
– CAPT?

– Best Climate Products

Extras

SO_4 compared with IMPROVE data





Unlikely to make CAM4

- subgridscale water variability -> Cloud Fraction
  - sub-column generator
  - radiation --> consistent heating & photolysis
  - microphysics
- alternate deep convection schemes
  - Bretherton shallow -> Deep (Bretherton UW, Mapes U. Miami)
  - Emanuel (MIT)